Weiguan Building

Summary Information about Building Performance during M6.4 Southern Taiwan Earthquake in February 2016

Gleaned from Media Sources and other Internet Information
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The Weiguan Building was a 17-story residential building in Yongkang District, city of Tainan, Taiwan. It was built in 1989-1992 (not clear, different sources).

When news reporters tried to locate the construction and engineering companies to blame, not surprisingly, they found that company had gone out of business. These corporations thrive upon quick construction work that easily generates a large amount of income with little to no governmental intervention. Construction was stopped when the first developer went bankrupt, being completed by a second company.

Two main firms that built the tower, Wei-guan Construction and Da Hsin Engineering, have since gone out of business. (www.thenational.ae)

Supposedly, it complied with local regulations in 1992, when it was built (www.nytimes.com). Modern building of the area remained intact.

Being Taiwan a very seismic region, due to the soft soil nature of Tainan, surface ground motion due to the traveling wave was strongly amplified, thus creating more devastating effects in Tainan.

The story of Wei-Guan Golden Dragon began in 1982, when rice farms in the area were rezoned to allow residential or commercial development. Under a pre-World War II regulation, since repealed, the site's location facing a six-lane road meant that a tall building would be permitted, Mr. Lee said, and that the facades could extend to the road's edge as long as sidewalk overhangs provided shelter from sun and rain.

The two sides of the U-shaped complex, 17 floors soaring straight up on columns, collapsed during the quake, Mr. Lee said; the third, with a load-bearing wall and **no overhang**, fell over sideways but **stayed more intact.**

Construction was bedeviled with problems, according to neighbors. Mr. Yang, the engineer who lives across the street, said the Wei-guan Construction Company ran out of money for the project in the early 1990s as it tried to build several buildings at the same time. It hastily erected the Golden Dragon's steel shell, then left it idle for months.

Hundreds of buildings in Tainan's Yongkang District are intact while the twin 17-story towers of the Weiguan Jinlong residential building were left lying on their sides on Yongda Road when the shaking stopped.

http://seismo.berkeley.edu/blog/seismoblog.php/2016/02/07/suspicious-collapse-of-twin-towers

The peak ground acceleration caused by the quake's seismic waves did not exceed more than 30 percent of a "g", the standard gravitational pull of the Earth. Seismic engineers call this amount of shaking "moderate". It will certainly be felt but should not lead to a catastrophic building failure, particular in a country like Taiwan, which has one of the most stringent earthquake resilient building codes in the world.

Damage in cities hit by moderate or strong earthquakes is never concentrated just in a single building. If only one building fails catastrophically and everything else is left standing with only cosmetic damage, one can only assume that the structure had a fundamental flaw in its design, or that its construction was very shoddy.

Pre-collapse

Figure 1: Pre-collapsed photo South-East corner (Source: http://goo.gl/V0rABg)

Figure 2: Pre-collapsed photo East side (Source: Google Map)

Figure 3: Pre-collapsed photo West Side (Source: google maps)

Figure 4: Pre-Collapse photo West Side (Source: google maps)

Post-collapse

Figure 5: Post-collapsed photo (Source: www.udn.com.tw)

Figure 6: Post-collapsed photo (Source: www.udn.com.tw)

Figure 7: Aerial post-collapsed photo
Source:
http://www.scmp.com/news/china/society/article/1910068/building-collapse-during-deadly-taiwan-earthquake-linked-shoddy

Figure 8: A more general view of one of the towers laying in the ground
Image by: https://en.wikipedia.org/wiki/2016_Taiwan_earthquake

Figure 9: Oil cans observed in parts of the structure which created a lot of controversy
Image by: Wally Santana/Associated Press obtained from:
http://mashable.com/2016/02/07/taiwan-earthquake-oil-cans/#nBFxABZ6zgqO

Figure 10: Cans in pillars
Source: https://twitter.com/Linde136/status/696286289474228225/photo/1

CNN mentions that oil tins have been found in beams, other sources state that these were placed in walls, being an incognita if those were resisting walls or just separation walls for floor distribution. They were reportedly used as lightening of the members. Not due to the fact that this practice doesn't seem very safe (Building code in Taiwan changed in 1994, after this building was designed and built) it is also the fact that the own execution of the project doesn't seem very right. The accumulation of the tins in one side of the member while pouring the concrete or some indices of cold joints in different photos can allow you to think about this idea.

In http://shanghaiist.com/2016/02/08/taiwan_earthquake_building_collapse.php mention that tin were found in the pillars: "In the wake of a 6.4 magnitude earthquake that struck southern Taiwan early Saturday morning, killing at least 37 and injuring hundreds more, controversy has risen from the discovery of cooking **oil and paint cans built into the pillars** of a 17-story building in Tainan that toppled in the quake, resulting in the majority of the casualties. However, at this point, experts claim that they were not responsible for the building's collapse." Still not clear where these were actually placed, if not all over the building.

Taiwan media has also reported the presence of polystyrene in supporting beams, mixed in with concrete. The Wei-guan, completed in 1994, was the only major high-rise building in the city of two million people to have completely collapsed.
(Source:
http://www.dnaindia.com/world/report-taiwan-developer-arrested-after-deadly-quake-fells-building-2176181)

Figure 11. We can see what might be the base floor columns totally teared off (maybe a case of soft story building?)
Image by: Yahoo News

Figure 12: Another image showing the collapse of the beams or slabs between the resisting walls.
Source: http://www.elitereaders.com/taiwan-tainan-earthquake-february-2016/2/

Figure 13: Complete debonding of reinforcement at connection is visible (Source http://www.adn.com/article/20160206/over-100-missing-14-dead-strong-quake-rattles-taiwan)

Figure 15:: Complete Overturning of base is observed
(Source: http://focustaiwan.tw/news/asoc/201602070017.aspx)

Construction of the building

It was a U-shaped residential complex with nine 17-story RC buildings built in 1994 with a height 52m and the original design drawing is shown below:

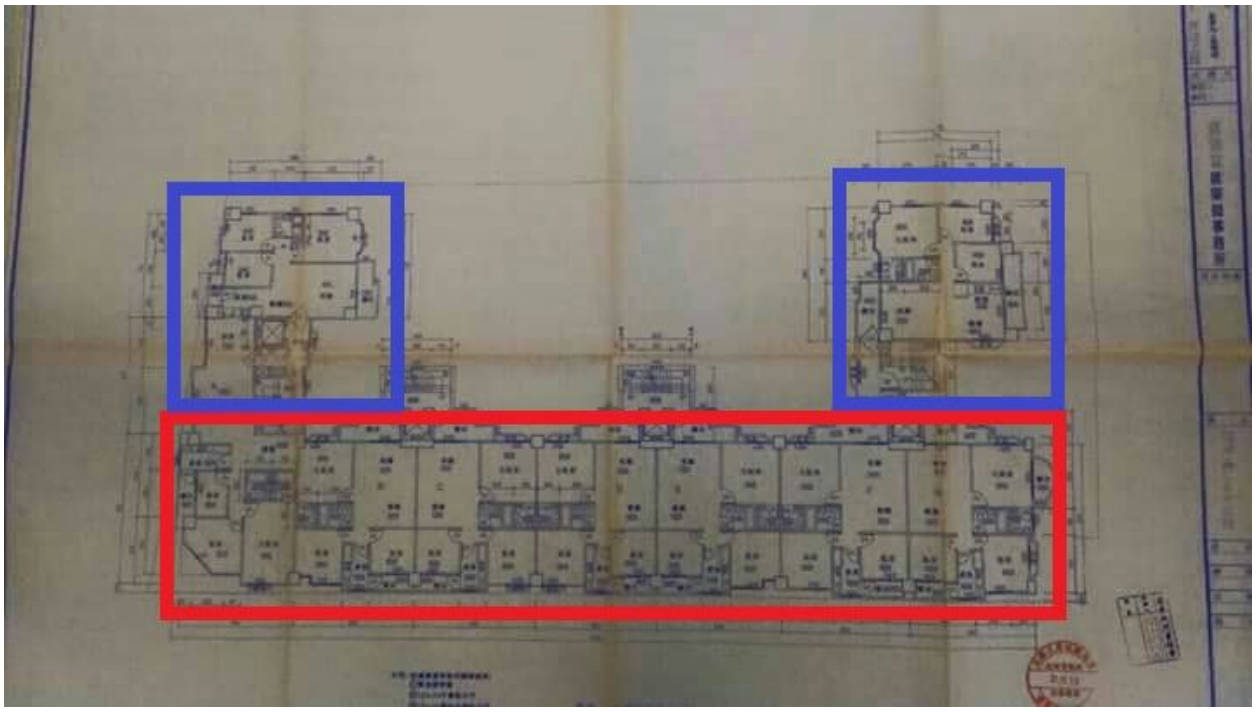


Figure 16: Original design drawing (Source: http://goo.gl/gjwNYU)

Other important information:

Used to be a **rice field** according to a testimony by a local found at:
http://www.nytimes.com/2016/02/09/world/asia/neighbors-had-doubts-about-complex-that-collapsed-in-taiwan-quake.html

The building collapsed and overturned to the street side. As clearly observed from the photos, there were no walls on the ground floor. Hence, there is a high likelihood that the basement acted as a soft storey and caused the building to collapse. (Generally, when shear walls are discontinued at a particular floor, the increased lateral demand is resisted by designing the columns for additional shear force. Hence, it would be worth observing if the ground floor columns were designed to handle the additional shear demand)

Another important thing to investigate is the plan of the building. The distribution of stiffness in the principal orthogonal directions needs to be investigated and could possibly explain why overturning occurred to a particular side.

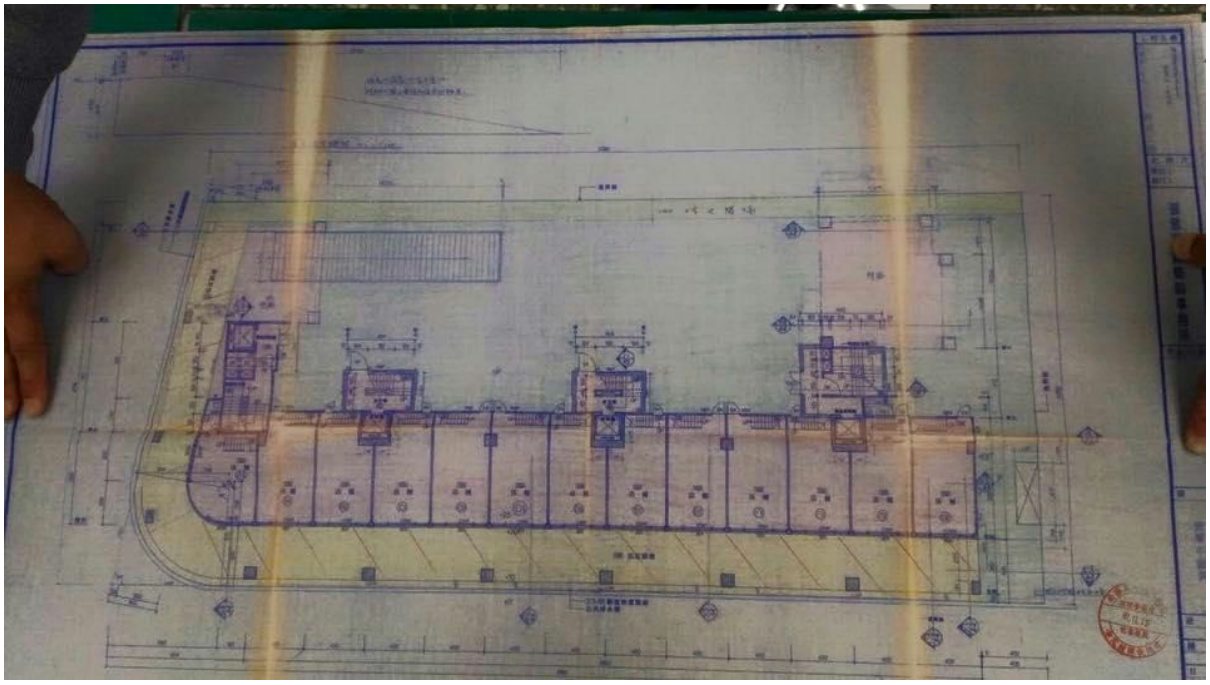
Also, the fact that the base columns completely teared off and the building overturned indicates that the connection between the building and foundation may not have been properly detailed.

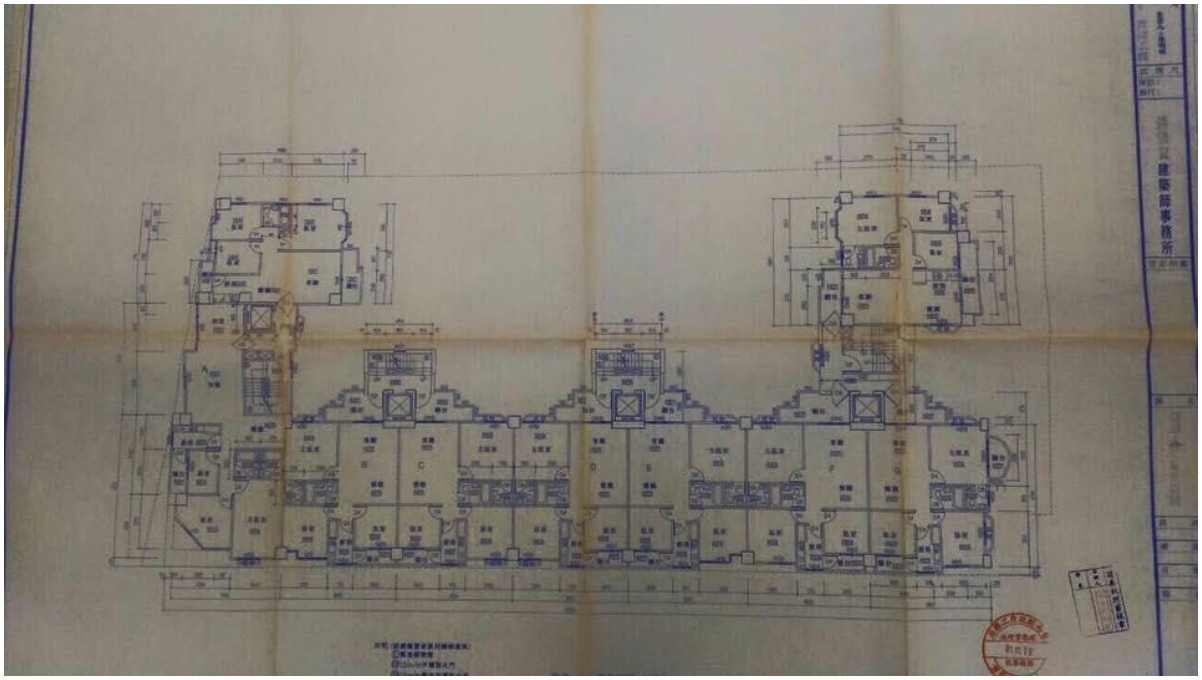
In photographs, the reinforcement seems to have either buckled, or decoupling of transverse and longitudinal reinforcement seems to have occurred. This indicates possibility of improper reinforcement detailing.

Additional Information

by: Gengrui Wei, University of Illinois Urbana Champaign

Design drawing of Weiguan building:





Drawings from a local engineer's Facebook

Source:
https://www.facebook.com/photo.php?fbid=1123884517644638&set=pcb.1123900787643011&type=3&theater

Report from Central News Agency, CNA, says that according to a victim of the earthquake, one of the reasons why the building collapsed may be that some resident in the building broke and cleared many infills and columns of a storey so that more rooms could be arranged for rent.

Report:http://www.cna.com.tw/news/firstnews/201602105008-1.aspx

Pictures from the victim's Facebook.

Source:
https://www.facebook.com/photo.php?fbid=1143542508996809&set=pcb.1143542552330138&type=3&theater